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THE ENGINEERING IN AGRICULTURE NEWSLETTER

FALL 1997

avec Agricultural Value-added Engineering Centre

Engineering Support for Value-added Processing

John Chang, AVEC Program Manager, Edmonton

The Agricultural Value-added Engineering Centre (AVEC) was launched in June 1997. AVEC is another initiative of the Engineering Services Branch, in its role of supporting the agriculture and food industry. The goal of the Agricultural Value-added Engineering Centre is to help meet the engineering-related needs of Alberta's growing agricultural value-added processing industry, in the food and non-food sectors. Funding is provided by the Agriculture and Food Council through the Canadian Adaptation and Rural Development Fund (CARDF), money provided by Agriculture and Agri-Food Canada.

The Agricultural Value-added Engineering Centre has three components: a Research Centre, a Resource Centre, and funding to support eligible projects.

AVEC Research Centre: Is located at the Ellerslie Research Station of the University of Alberta (on 127th Street, 1.2 km south of Ellerslie Road in south Edmonton). Research will be directed toward finding solutions and developing information to address the industry's problems and needs. The Research Centre is ready to work with industry partners, educational and other researchers. We are very interested in cooperative projects and other partnering opportunities.

Resource Centre: Is located in Room 201, J.G. O'Donoghue Building, 7000 - 113 Street, Edmonton. The Resource Centre provides a variety of engineering-related information sources (books, magazines, and commercial literature) and other resources to help meet the needs of the processing industry and its service sector. In addition, a public kiosk computer has been set up with an organized set of bookmarks to Internet sites covering a wide range of information on agricultural processing.

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Alberta
AGRICULTURE, FOOD AND
RURAL DEVELOPMENT
Engineering Services

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The purpose of this newsletter is to advise of activities and projects being conducted by Alberta Agriculture, Food and Rural Development's Engineering Services and Regional Agricultural Engineering staff. For further information on these projects and other engineering related activities contact:

Lethbridge	381-5112	Airdrie	948-8525
Red Deer	340-5322	Vermilion	853-8224
Barrhead	674-8256	Fairview	835-2291
Edmonton (Eng. Services)	427-2181	Lethbridge (AFMRC)	329-1212

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The need for information on the planning and design of new processes and facilities, processing equipment, services and other related subjects is one of the basic requirements that most clients have.

Project Funding: Financial assistance is available to provide shared funding for projects directed toward engineering-related needs of the agricultural processing industry. Priority will be given to projects designed to provide engineering support for the industry to: acquire basic knowledge and skills for processing development; solve critical, industry-wide problems; or foster the adoption of key technologies. Assistance is available to individuals, organizations or companies.

Personnel: AVEC Program Manager: John Chang; Research Centre: Kris Chawla; Research Engineers: Lope Tabil, Hong Qi; Resource Centre: John Kienholz; Project Funding: Marshall Eliason.

Please contact us if you have any questions, suggestions, or if we can be of assistance.

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Feedlot Runoff

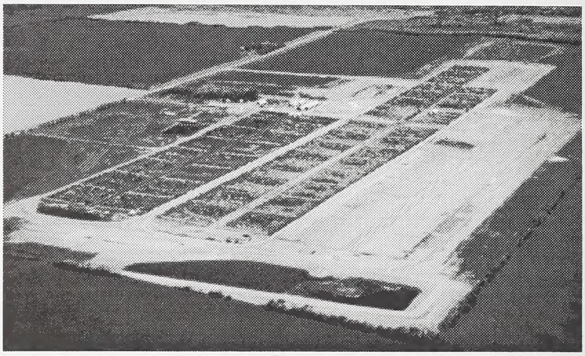
Brian Kennedy, Agricultural Engineer, Vermilion

Conceptually, a feedlot pen surface is a sponge on top of an impervious layer. The sponge soaks up rainfall and does not release water until it is full. The impervious layer prevents downward movement of nutrient rich liquid into the soil profile.

In our climatic conditions, the manure pack functions as a sponge. Under the action of animal feet, dirt pen surfaces soon pack and incorporate manure into the top surface. What then develops is a gleyed layer of manure at the manure soil interface. It is impervious and overlain by the manure pack. A portion of the rain that falls on the manure pack surface is absorbed into the manure pack.

A recent CAESA (Canada/Alberta Environmentally Sustainable Agriculture Agreement) funded project measured the runoff from a commercial feedlot near Vegreville. Over the four year project, 26 rainfall events occurred, producing runoff. Two types of storms were observed:

1. Short, intense thunderstorms, producing small amounts of runoff.
2. Frontal storms of long duration and low intensities, producing significant, though delayed, runoff.



Feedlot pen soils have runoff and erosion characteristics similar to those of Alberta's Luvisolic and solonetzic soils. These soils have the highest runoff and erosion potential of the province's soils. A conceptual model of a feedlot soil is a Solonetz soil covered with 10 cm of peat. In Alberta's semiarid climate, the manure layer provides a large storage reservoir sufficient to store the rain from most storms. Once the manure is saturated, the hardpan directs all the rain to runoff so that runoff quantities increase with long duration storms, or with a sequence of back- to-back storms. Once the manure pack is saturated, high runoff volumes cause the manure pack to erode. This transports manure solids. Well-graded pens and ditches, typical of modern feedlots, will transport more manure solids, not less, as a major runoff producing storm continues.

Runoff yields from individual storms (with a return period greater than 1:10) averaged 33 percent. With yearly emptying of the catch basin (focusing on the 1:10 wettest year), it is now common practice to use the 1:25 year, 24-hour storm to design the size of the catch basin.

In summary, feedlot runoff control facilities must remove surplus water from the manure pack during a storm event, settle eroded material into an area from which it can be removed, and store expected volumes of runoff.

Residue May Restrict Crop Emergence

Murray Green, Farm Machinery Engineer, Airdrie

An unexpected observation was made on a direct seeding project this year. The barley emergence and early growth were quite poor on many plots. The problem appeared to be related to crop residue.

The wind and rain that occurred four days after planting moved a lot of the loose residue into the seed row furrow. This resulted in a severe restriction of the emerging barley. Our assessment was the barley developed its first leaves while still below the residue and was mechanically restricted from emerging. The stress the crop encountered was further aggravated in the low fertilizer treatments and where the seeding rate was low (not planned for in our project). No doubt, microorganisms associated with the residue were also having their influence.

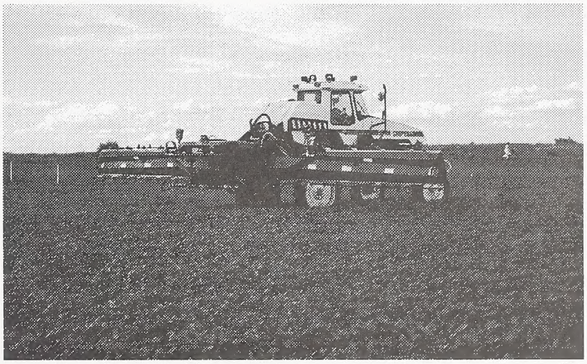
We looked at several farm fields which showed similar signs. Again, simple mechanical restriction to emergence was suspected. This prompted us to develop further tests to determine just how much residue crops can emerge through. The problem is most likely to be seen in the black soil zone.

What can be done if one suspects this problem? In direct seeding, there should be little residue left on top of the seed row and, most certainly, not piles of residue. Small piles of residue result when too thick a mat of residue exists on the surface. Too much chopped residue on the surface can easily move onto the seed row, such as what happened in our case, and restrict emergence. Leaving taller stubble will help reduce this. Harrowing after planting can move residue from the inner row area onto the seed row. On the other hand, if the residue has already ended up on the seed row, harrowing may relieve the problem.

New Spraying Techniques

Brian Storozynsky, Field Technologist, AFMRC, Lethbridge

Several spraying technologies developed in the last couple of years are now available to producers and custom applicators. Melroe's *Energized Spray Process* (ESP) system, Spectrum's *Electrostatic/Air System*, Spray-Air's *Shear Guard Plus* system and Greenleaf Technologies *TurboDrop Venturi* nozzles all incorporate new spraying technologies. These new spraying technologies are available in accessories which can be fitted to existing sprayers, or as optional equipment when purchasing a new sprayer. All use air and/or electrostatics to improve the transport of a spray droplet to its intended target. The new spraying technologies are introduced in crops where increased spray penetration, retention, coverage and reduced spray drift are needed. Improved spray deposition means less adverse environmental impact with increased production if biological activity is improved. The additional cost of these new spraying systems can range from $1,000 to $50,000.



Melroe's Energized Spray Process (ESP)

Due to a very competitive spraying industry, new spraying technologies are quickly introduced into the market without much research data on their effectiveness. For the most part, chemicals applied according to label rates are effective in a wide range of growing and spraying conditions, making it

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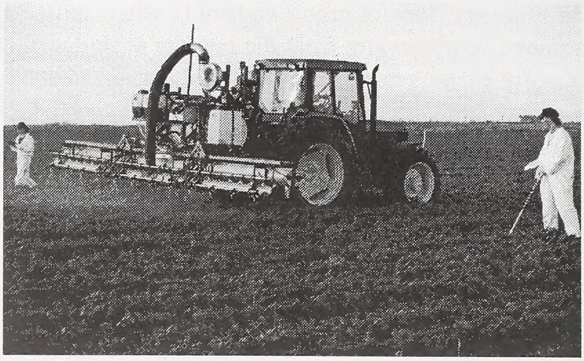
difficult to prove the new spraying technologies' effectiveness, and therefore, whether the extra cost is worth it. In the past, some sprayer manufacturers marketed their spraying techniques by claiming less water and chemical could be applied than stated on chemical labels. AFMRC's experience has been that the manufacturer's own research data tended to be biased. Some of the new spraying technologies tested by AFMRC even had adverse effects (e.g., increased spray drift), and others just optimized herbicide effectiveness rather than creating improved "killing power" when compared to conventional spraying. Do the new spraying technologies have the extra "killing power" needed to convert producers?

Due to the size of some new spraying systems, the power, and cost required to operate them, chemical companies and sprayer manufacturers find it difficult to incorporate these sprayers into typical scientific research programs. Also, sprayer manufacturers are reluctant to give up a unit worth $150,000 for research. Lack of research data leads toward producer skepticism and most new spraying technologies cannot find a market niche. To encourage chemical companies and researchers to use the new spraying technologies for herbicide efficiency studies, AFMRC has built two research sprayers, each with a 6 m spraying width. One research sprayer is equipped with the following new spraying technologies: Willmar's *TriMizer* system, Spectrums electrostatic/air system, Spray-Air's new *Shear Guard Plus* system, Melroe's *Energized Spray Process* (ESP) and Greenleaf's *TurboDrop Venturi* nozzles. The other sprayer is equipped with conventional and turbo nozzle systems and other spraying technology, such as the Kaletsch rotary fans and Kyndestoft's vacuum sprayer. The various spraying systems were given to AFMRC by the manufacturers to encourage spray research. Other spraying refinements will be added as spraying technology advances.


AFMRC's Research Sprayer

The long term goal is to start registering chemicals with the new spraying technologies. Due to state-of-the-art monitoring, chemical injection, auto-control systems used, and power required, these sprayers will be available with both operators and tractors. Since AFMRC's mandate is to promote new technology, the cost to potential clients will be small.

Livestock Expansion and Development Team

Louise Starling, Communications, Red Deer

Alberta Agriculture, Food and Rural Development is committed to ensuring that agricultural development is accomplished in a responsible manner. The Livestock Expansion and Development Team, headed by Dr. Terry Church, are addressing issues and concerns associated with the growth of the livestock industry. Together, the Team brings considerable experience and knowledge working with the agriculture industry in Alberta. Team members are:
Terry Church - Team Leader
David Helmer - Intensive Livestock Research
Darcy Fitzgerald - Environmental Management
Louise Starling - Communications
Murray Davison - Business Development
Brian West - Animal Waste Management
Darlene Albrecht - Client Services.

We're on-line! Visit us at:
www.agric.gov.ab.ca/esb/index.html

Partnering for success, Alberta Agriculture, Food and Rural Development will continue to work with municipalities, developers, and the public to strengthen the existing municipal development process. Engineering staff and the Livestock Expansion and Development Team are two of several partners working to ensure livestock operations are planned responsibly, distanced from neighbouring rural residences and urban areas, use advanced nutrient management technologies, and are sensitive to their neighbours' concerns and consult with them.

Some of the projects the Team are currently working on include:

- Research to address odour prediction and control, seepage from earthen manure storage lagoons, manure treatment and handling, and environmental impacts to watersheds.
- A 1998 version of the *Code of Practice for the Safe and Economic Handling of Animal Manures*.
- Strengthening our relationship with Alberta municipalities by supporting practical bylaws and responsible decision making.
- A display illustrating the social and economic benefits of livestock operations to the community.
- A *Developer's Guide* for establishing and managing livestock operations.

Resource materials available from the Team are:

- Development Permitting Process for New and Expanding Intensive Livestock Operations
- Services and Infrastructure for 1,000 Sow Farrow to Finish
- Business Plans for Pork Production Operations Factsheet
- Resources for Beef Industry Expansion in Alberta
- AG-Ventures, Agriculture Business Profiles

The Livestock Expansion and Development Team can be contacted directly by calling (403) 340-5359, or through any of AAFRD's District Offices. Our e-mail address is:
darlene.albrecht@agric.gov.ab.ca.

Code of Practice to be Revised

Brian West, Animal Waste Management Specialist, Red Deer

After only two years, plans are underway to revise the *Code of Practice for the Safe and Economic Handling of Animal Manures*. Although the *Code* has served us well, the high level of livestock expansion activity and the rapid increase in development size necessitates the *Code* be kept up-to-date. Revisions will be multidisciplinary with input from the agronomy, crops and irrigation expertise in the Ministry. It is important that the revisions be validated by the industry so a review process will be needed. While Darcy Fitzgerald and Brian West will focus on the engineering input, all staff will have an opportunity to contribute.

Measurement of Odour from Livestock Facilities

Brian West, Animal Waste Management Specialist, Red Deer

Alberta is taking the lead role in developing odour management technology. Odour measurement is seen as an important requirement in the evaluation of new odour abatement techniques. It will also provide the capability to validate dispersion modelling of odour emissions. The development of this expertise is helpful in the orderly planning of our rapidly expanding livestock industry.

Expertise in two types of odour measurement technology is happening here. Dr. Richard Coleman, from the Alberta Research Council in Vegreville, will be testing and applying the "scentometer" approach. This involves a purely analytical approach to odour intensity and quality. This device "fingerprints" each odour through an array of sensors, each sensitive to a specific odour compound. Each type of odour will have its own typical profile or fingerprint.

The other method of measuring odour is the use of an "Olefactometer". This device permits the mixing of odourous air with clean air in specific ratios to the point of odour threshold. A test panel is used to

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determine the odour threshold level which is expressed in "number of dilutions to threshold level". The greater the number of dilutions, the stronger the odour intensity.

David Helmer, research engineer with the Livestock Expansion and Development Team, will be assisting in the coordination of these projects. The progress of this study will have large implications for all Engineering staff involved with ILO developments.

How to Match Pig Cycles to Barn Design

Robert Borg, Agricultural Engineer, Red Deer

The best design for a swine barn matches the pig's biological cycle to the layout of the barn. Barns are expensive and good pig flow makes best use of all the available resources - facilities, feed, and labour. The cycle of pig production includes breeding, gestation, farrowing, weanling, grower, and finisher stages. Barns are built with separate rooms for each phase of production.

To illustrate the flow of pigs, an example of a barn producing five litters of piglets per week (5 L/wk) is used. *Figure 1* shows groups of five pregnant sows leaving the breeding gestation room and moving to the farrowing room. After all the litters of piglets are born, they nurse for four weeks (depending on the management system). After the nursing period the piglets are weaned from the sows and move through weaner, grower, and finisher rooms on their way to market. The weaned sows move back to the breeding/gestation room to repeat the cycle again.

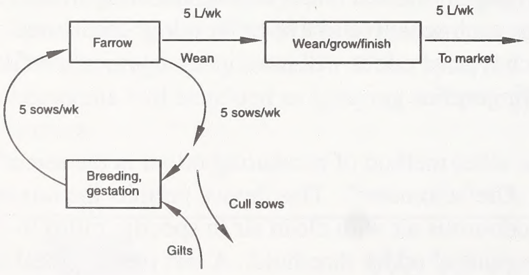


Figure 1. Pig Flow

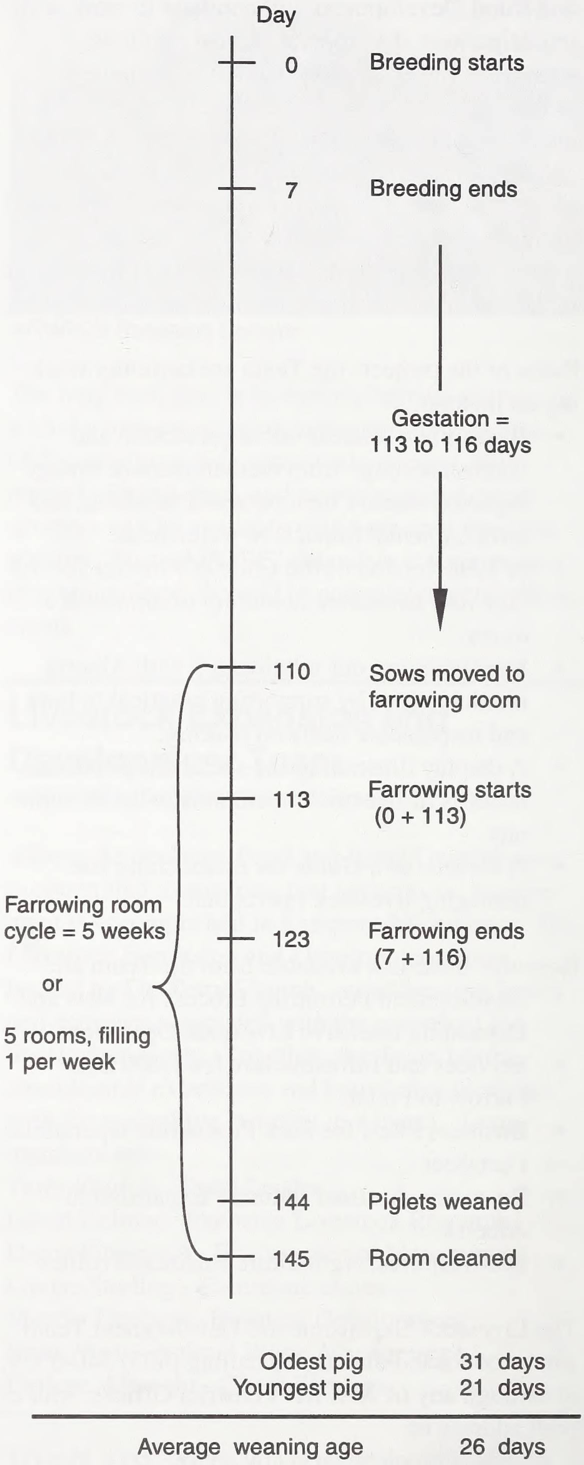

Day
0
Breeding starts
7
Breeding ends
Gestation = 113 to 116 days
110
Sows moved to farrowing room
113
Farrowing starts (0 + 113)
Farrowing room cycle = 5 weeks
or
5 rooms, filling 1 per week
123
Farrowing ends (7 + 116)
144
Piglets weaned
145
Room cleaned
Oldest pig 31 days
Youngest pig 21 days
Average weaning age 26 days

Figure 2. Sow Cycle Time Line

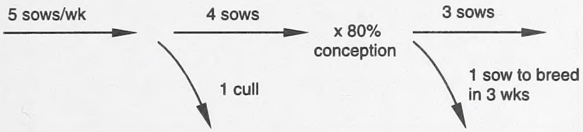
One way to describe this barn is by the herd size and productivity. If each sow produces 2.26 litters of piglets per year, the herd size is:

$$\frac{\text{5 Litters per week x 52 weeks per year}}{\text{2.26 Litters per sow per year}} = 115 \text{ sows}$$

Sow Cycle

The sow cycle for this barn is shown in *Figure 2* as a time line. Variation is introduced depending on the day the breeding is completed, and the fact that average gestation time may vary from 113 to 116 days. Average weaning age in this example is 26 days.

Not all sows flow smoothly through the barn. About 20 percent of each group of sows are culled each cycle. Also, only 80 percent may be successfully bred the first time. There may only be three sows left in the original group of five. The difference of two sows per week is made up by breeding sufficient replacement gilts and repeat sows.



For this herd, the average cycle time for each group of sows is: 52 weeks ÷ 2.26 Litters/sow = 23 weeks (farrowing + gestation + nonproductive days) or 18 weeks in the breeding/gestation barn and five weeks in the farrowing barn.

Breeding/gestation	18 wks x 5 sows/wk	= 90 sows (plus gilts and boars)
Farrow	5 wks x 5 sows/wk	= 25 sows
Total	23 wks	= 115 sows

Piglet to Finisher Flow

In this design, piglets are formed into three groups of 16 pigs per week. This is based on an average litter size of 9.6 pigs weaned per litter.

5 Litters/week x 9.6 pigs/Litter = 48 pigs/week.

Pen sizes are based on 3 ft^2/pig for weaners, 6 ft^2/pig for growers, and 9 ft^2/pig for finishers.

Farrowing room	4 weeks
Weaner room (5 rooms, fill one/week)	5 weeks
Grower room (3 pens/wk x 8 = 24 pens)	8 weeks
Finisher room (3 pens/wk x 8 = 24 pens)	8 weeks
Age to market	25 weeks

Barn Layout

The last step is an actual barn layout. *Figure 3* shows a real barn using the pig cycles developed in this article.

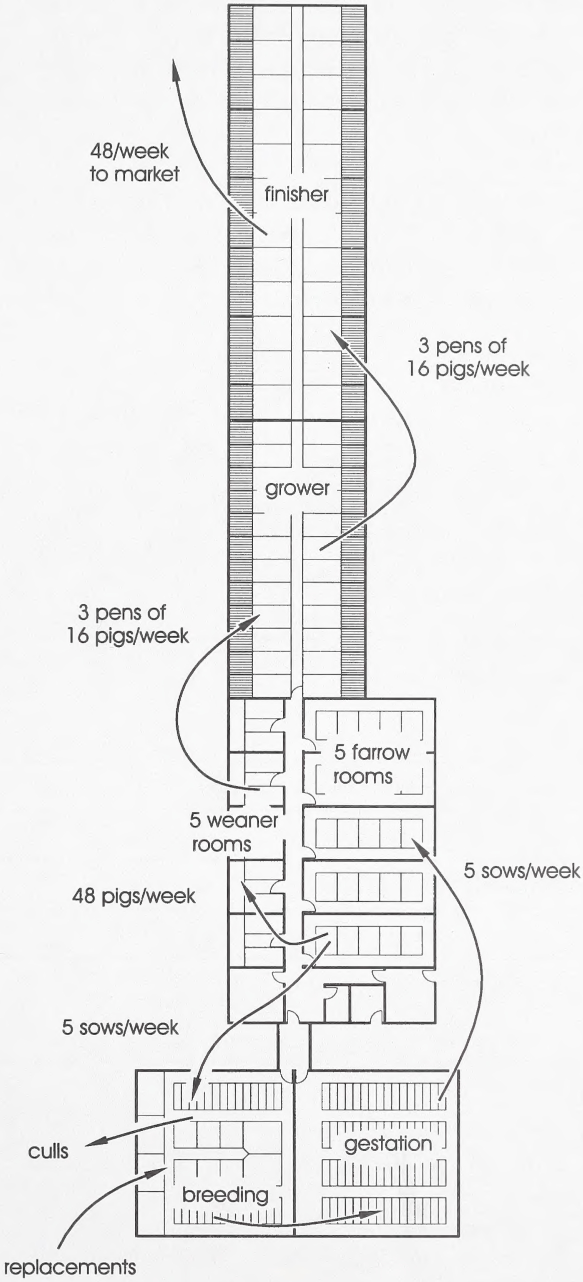


Figure 3. Barn Layout

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Infrastructure and Resources for Large Swine Facilities

Dennis Darby, Structures Engineer, Lethbridge

The planning and evaluation requirements for large swine facilities involve thinking on a larger scale than has been done in the past. A team of engineers and swine specialists from Alberta Agriculture, Food and Rural Development recently compiled a summary table of the requirements for large (1,000 plus) sow operations currently being developed on the prairies.

Large swine facilities differ in several aspects from the traditional family farm operation. A so-called "large" facility has the following characteristics:

- Larger than 500 sows.
- The sow unit, farrowing and breeding centre, will probably be separate from the weaning and rearing facility.
- One large farrowing centre will supply pigs to several satellite weaning and rearing units.
- Weaner and finishing barns are likely to be multiple room "all in - all out" facilities.

The resources and facilities required for a typical 1,000 sow operation are listed in the table below. The logic and planning processes vary slightly, depending on production and management variables. This table can be reasonably expanded to accommodate up to a few thousand sow capacity.

Building & Facilities Summary for 1000 Sows

Building areas - square feet (ft^2)		Weaner Facility for 2700 @ 4.0 ft^2	10,800
Dry sow area: 840 stalls @ 22 ft^2	18,500	8 rooms of 1350 ft^2	
Breeding area (AI): 10 boar pens @ 50 ft^2	500	Grower-finisher (24 - 110 kg) all in - all-out barn(s) for 8,000 feeders @ 9.5 ft^2	76,000
Breeding area (natural): 45 boar pens @ 50 ft^2	2,250	Other areas required	varies from
12 breeding pens @ 100 ft^2	1,200	Mechanical rooms, offices, AI lab	2500 - 4000
Replacement stock in group pens			
50 replacement gilts @ 12 ft^2	600		
Farrowing Facility, 176 crates in 8 rooms	11,500		

Resources & Utilities		**Gestation - Farrow**	**Weaner**	**Grower - Finish**	**Total**
Total building areas - square feet (ft^2)		30,000 - 33,000	10,000 - 11,000	75,000 - 78,000	115,000 - 122,000
Water required - Imperial gallons (per day/year)		6,000 / 2,200,000	1,500 / 550,000	15,000 / 5,500,000	22,500 / 8,250,000
Feed required - tons per year		1,000	650	6,800	8,450
Power to site - kVA					Approx. 250 kVA
Natural gas (or equivalent) - m^3/hour		40	15	20	75
Manure storage required - ft^3	For 200 days	130,000	10,000	350,000	490,000
	For 1 year storage	240,000	18,000	640,000	898,000
Typical 1-year lagoon size, including 2 ft. freeboard		160 x 160 x 15 ft.	--------	225 x 225 x 20 ft.	250 x 250 x 20 ft.
Land for Manure Application	Brown soil	500	50	1360	1910
Acres for soil type	Grey-wooded	420	40	1130	1590
Manure applied annually	Black soil	320	30	850	1200
	Irrigated	260	20	680	960

Notes:

1. Water requirements allow for clean-up and wash water
2. Areas for manure are derived from the Code of Practice and are for initial planning purposes. Exact design depends on soil type and cropping practices
3. Weaner facility is usually separate from the breeder - farrow unit
4. Building areas are gross area, allowing for alleys and partitions